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# The effect of turbidity on the transition from social to sexual behavior in an African cichlid fish

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## INTRODUCTION

- Aquatic ecosystems are increasingly affected by human-induced stressors (e.g. elevated turbidity)[1,2].
- Light scattered by particles in the water column will alter the effectiveness of visual signals[3,4].
- *Pseudocrenilabrus multicolor victoriae* (a widespread African cichlid fish; Fig. 2) rely on visual cues such as male coloration and courtship displays for reproduction[1,4].
- To compensate for environmental stressors, fish must adapt behaviorally, morphologically, and physiologically, or face extinction[1,2,4].
- Evidence suggests that fish in turbid water often exhibit behavioral energetic trade-offs to persist[2,5,6].

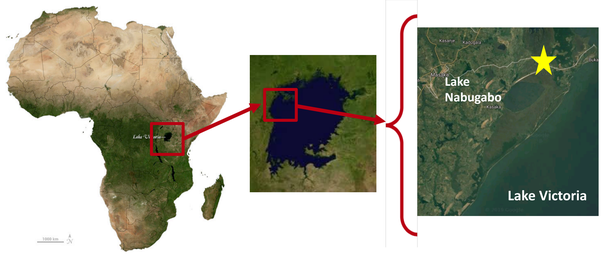



**Figure 1.** Lwamunda Swamp (star) borders much of Lake Nabugabo, a satellite lake of Lake Victoria, Uganda, Africa.

## OBJECTIVE

- To determine if exposure to elevated turbidity will alter the developmental transition from ecological behaviors (e.g. feeding, social) to reproductive behaviors (e.g. courtship displays) in the ontogenesis of *P. multicolor* (Fig. 2).

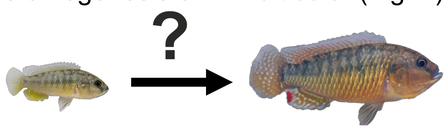



**Figure 2.** A juvenile *P. multicolor* (left) will begin displaying predominantly reproductive behaviors, rather than ecological behaviors, as an adult (right).

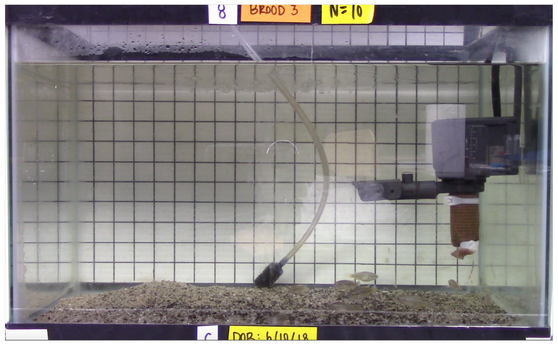
## PREDICTION

- We predicted fish reared under turbid conditions would switch from ecological to reproductive behaviors earlier than those reared under clear conditions.

## METHODS

- Ten independent broods of F1 *P. multicolor,* parental population originating from Lwamunda Swamp, Uganda, Africa (Fig. 1), were reared.
- Broods were split two weeks post-hatch and assigned to either a clear or turbid treatment (10 broods x 2 treatments= 20 tanks) (Fig. 3).
- Turbid tanks were maintained at ~10 NTU to mimic conditions in natural rivers.
- Beginning at three weeks post-hatch, each tank was filmed once a week for 20 min. (10 min. acclimation + 10 min. observation).
- Filming was concluded at 20 weeks of age (considered avg. age of sexual maturity in *P. multicolor*[3]).
- A subset of videos (n=75) were analyzed by performing focal follows on one male/tank and enumerating ecological and reproductive behaviors performed for the proportion of time active.

A)




B)

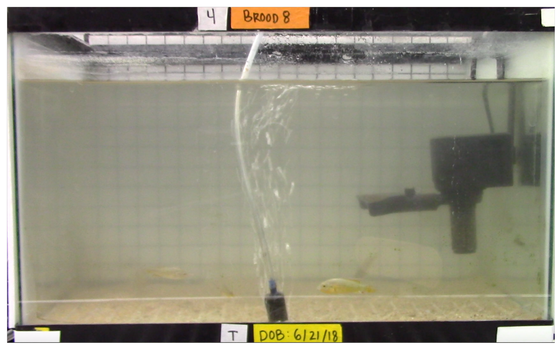



**Figure 3.** Half of each brood was reared under A) Clear conditions (~ 0 NTU) and the other half under B) Turbid conditions (~ 10 NTU).

## RESULTS

- Fish in clear and turbid tanks spent the same amount of time being active (Fig. 4).
- With age, fish in both treatments performed fewer ecological behaviors and more reproductive behaviors; however, fish in turbid tanks performed more feeding behaviors overall (Fig. 5).
- The proportion of sexual behaviors, relative to total behaviors, increased with age in both treatments; however, fish in clear tanks performed significantly more sexual behaviors than those in turbid tanks (Fig. 6).
- Fish in clear tanks exhibited a shift from ecological behaviors to reproductive behaviors significantly earlier (8.5 weeks) than turbid-reared fish (12 weeks) (Fig. 7).

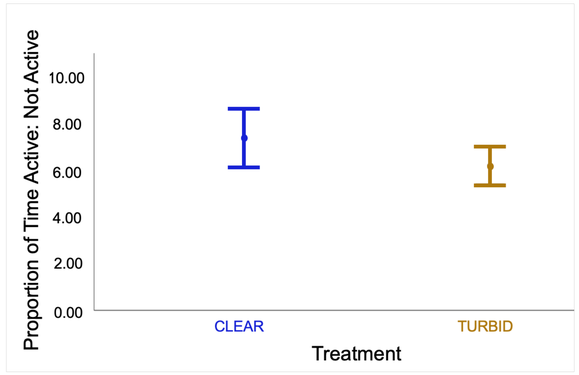



**Figure 4.** Mean (±SE) proportion of time spent active to inactive in fish reared under turbid and clear treatments ($F_{1,73}$= 0.613, p=0.436).

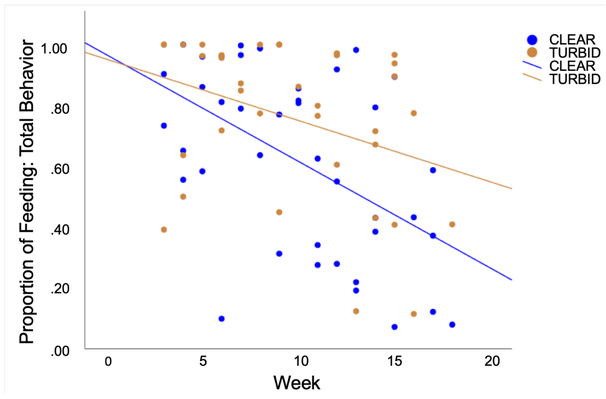



**Figure 5.** Proportion of feeding behaviors to total behaviors in clear and turbid tanks over 18 weeks (Clear: Pearson's r= -0.508, $t_{38}$=-3.638, p< 0.001; Turbid: Pearson's r= -0.398, $t_{33}$= -2.497, p= 0.017).

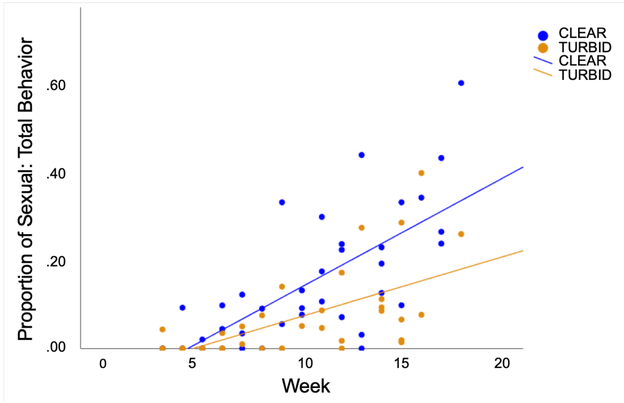



**Figure 6.** Proportion of sexual behaviors to total behaviors in clear and turbid tanks over 18 weeks (Clear: Pearson's r= 0.758, $t_{38}$= 7.175, p< 0.001; Turbid: Pearson's r= 0.688, $t_{33}$= 5.448, p< 0.001) .

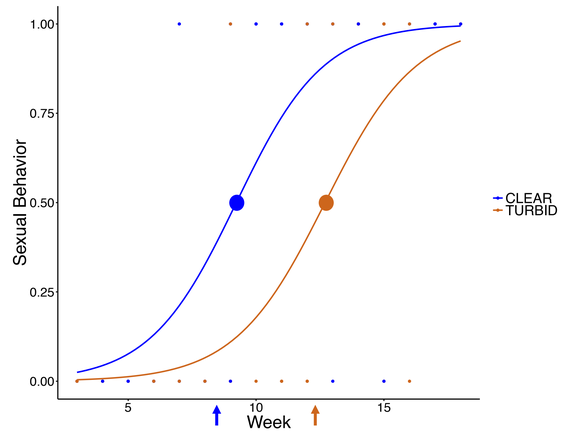



**Figure 7.** The transition from ecological (<10%) and reproductive behaviors (>11%) over 18 weeks (Clear: $z_{1,39}$= 3.42, p= 0.0062; Turbid: $z_{1,34}$=2.941, p= 0.003).

## CONCLUSION

- Exposure to a novel environmental stressor, such as turbidity, may cause fish to reproduce later in their development.
- This may have various detrimental effects on the overall fitness and persistence of *P. multicolor* populations[7,8].
- Ultimately, this could pose a threat to the structure and function of Lake Victoria's food web[7,8].

**LITERATURE CITED:** 1. Gray *et al*. 2011. *Ecol Freshw Fish* 20: 259-236. 2. Reid *et al*. 2018. *Biol. Rev.* 3.Gray *et al*. 2012. *Curr Zool* 58:146-157. 4. Seehausen *et al.* 1997. *Science* 277:1808-1811. 5. Candolin, U. and J. Heuschele. 2008. *Trends Ecol Evol* 23:446-452. 6. Järvenpää, M. and K. Lindstöm. 2004. *Proc R Soc Lond [Biol]* 271:2361-2365. 7. Seehausen et al. 2008. *Nature* 455:620-626. 8. Henley et al. 2002. *Rev Fish Sci* 8:125-139.

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